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Reducing the availability of food to control feral pigeons: changes in population size and composition

Running title: Integrated management of feral pigeons

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BACKGROUND: Since feeding by humans is one of the main food resources to pigeons (*Columba livia*), there is general agreement that public education that aims to reduce the food base may be the most feasible way to reduce pigeon abundance. However, except for the classic example of Basel, the method has rarely been tested or implemented. We provide results from a one-year study in the city of Barcelona where we tested the effect of public education on pigeon population abundance and composition.

RESULTS: The quantity of food provided by people to pigeons was significantly reduced during the study. Feral pigeon density was reduced by 40% in the two experimental districts, but no variation was detected in the control district. Detailed analyses in one of the districts showed that the reduction was mainly related to the reduction in food availability but not to culling. Pigeons captured at the end of the experiment were larger than at the start of the study but body condition was reduced.

CONCLUSION: Results show the effectiveness of public information to manage feral pigeon populations in a large city and that control operations can exert important selection pressure on the population leading to changes in population composition.

Key words: Feral pigeon, population size, public information, food reduction, culling.

1. INTRODUCTION

The size of the populations of feral pigeons *Columba livia* has increased dramatically in many cities during the second half of the 20th century both in Europe and in North America [1]. This increase has been associated with many problems related to the damage to urban architecture and the transmission of infectious diseases [1-4], hence giving rise to an increasing concern by city authorities and managers. Since damage is related to the number of pigeons [5], we have to reduce their numbers if we want to reduce pigeon damage in cities.

Many methods have been suggested to reduce urban feral pigeon populations [4,6-10]. Nevertheless, population models suggest that restricting the availability of food and nesting resources in the city should be the most effective and long-lasting method [4,9]. Since feeding by humans is one of the main food resources to pigeons, public education that aims to reduce the food base may be the most feasible way to reduce pigeon abundance [1,5]. The method was successfully implemented in Basel [5] in the 1980s and more recently in Venice [4]. However, implementation in a large city with high pigeon density [11] and where dispersal movements between close areas can be important may entail more difficulties than in other locations. For instance, Basel had a density of 840 pigeons/km^2 [5] before public information programs were undertaken while Barcelona has a density of 4,242 pigeons/km^2 [12]. Movements within the city between close areas are also important in Barcelona [13] and they could limit the success of a public information program about pigeon control. Additionally, and for a proper validation of the method, control populations should also be used to ascertain whether the reduction in feral population is the result of management operations or natural fluctuations in the population.

A topic of great interest from an evolutionary perspective is that reducing food availability and distribution could exert selection pressure that could change population composition and hence select the population towards a different optimum [14,15]. In feral pigeons it has been shown that in urban populations fed by people birds adopt a sit-and-wait foraging strategy which selects for longer tarsi, while short tarsi are selected for in populations with less feeding by humans, which promotes active searching for food [16].

The aim of this work was to test the success of feral pigeon management based on public education combined with culling operations in Barcelona where pigeon density is high. We used a design with experimental and control areas. A successful public education should entail a reduction in the quantity of food available to pigeons along the study. As a consequence, we should expect a concomitant reduction in pigeon density in experimental areas compared to the control one. We predicted that if public education was the main reason for the reduction in pigeon density, population size reduction should better correlate with the quantity of public informed than with culling effort. Additionally, because of the fact that larger individuals may enjoy a priority of access to the reduced food supplies [17,18], we predicted an increase in the size of the pigeons along the study.

2. MATERIAL AND METHODS

The study was carried out in Barcelona city in 2009. Barcelona has an area of 102 km^2, 72% of which is built up. The city is divided into ten districts and 73 neighbourhoods, which allows decentralized local administration. The experimental study was carried out in two districts: Sant Andreu [SA] and Horta-Guinardó [HG]. In SA we sampled four neighbourhoods: 1. Navas, 2. Congres i els Indians, 3. La Sagrera and 4. Sant Andreu. In HG we sampled two neighbourhoods: 5. Guinardó and 6. Baix Guinardó (Figure 1). An additional neighbourhood (7. Vilapicina-Torre Llobeta), within the district of Nou Barris, was used as a control area where no experimental action was carried out. We choose this neighbourhood as a control area because it was adjacent to the two experimental districts, so that habitat structure and socioeconomic variables were quite similar, and because it was someway in between the two experimental districts. We used squares of 250x250m (6.25 ha) as the sample unit (Barcelona contains 1,568 of these units). The size of this unit was determined on the basis of the home range area of pigeons in Barcelona, which is about 3.5 ha [13]. The study was based on a total of 44 experimental (32 in SA and 12 in HG) and 12 control squares. The size of the control area was smaller than the SA experimental area, but similar to the size of the HG experimental area. In any case, we thought that 12 sample control units should be enough to ascertain whether the reduction in feral population was the result of management operations or natural fluctuations in the population. As a consequence, we preferred to concentrate efforts in increasing the number of sample units in SA to allow for a powerful multiple regression, within the same district, to test for the differential effect of public information and culling efforts on population size reduction (see below).

In the six experimental neighbourhoods we carried out a campaign of public education, aimed to reduce the food base for pigeons. The campaign started on 1st February 2009 and finished on 22th February 2010. It consisted in distributing a pamphlet explaining the negative effects of feeding pigeons both for pigeons and for the public in a similar way as in Haag-Wackernagel (1995). We used seven city council information agents to contact people in city parks, gardens and streets for every working day from 0800 to 1200 hours (or from 0900 to 1300 hours, depending on the week). The agents explained the content of the pamphlet making an especial effort to inform people which were observed feeding pigeons. They also informed the local shopkeepers about the project. In total, we contacted 2,190 citizens. The information agents collected also data on the number of individuals engaged in feeding pigeons (N= 74) and the availability of food for pigeons disposed in the streets (see below). We also established three capture sessions with the elimination of individuals (pigeons culled: 06/03/09: 5,935; 03/07/09: 4,083; 13/11/09: 2,252). As in Haag-Wackernagel (1995) culling was done to adapt pigeon population size to the reduced food supply initiated by the public restriction of feeding. Pigeons were captured using pneumatic cannon nets. Capture areas were baited at the point of capture during 4-5 days prior to capture to increase success.

The experimental and control squares were surveyed by walking along all the roads in each sample unit (circuitous path) where we counted all visible pigeons (quadrate counts)[19,20]. Because a part of the population can be hidden and remain undetected bird detection probability must be considered [20-24]. In previous work we derived a correction factor of 3.5 to account for detectability of pigeons based on a double sampling procedure [19] using visual surveys and capture-recapture approaches [20]. This value was consistent across different cities [20,25,26], and so we assumed that although the index for Barcelona was derived many years ago, it could also be used now to estimate feral pigeon population size. We are uncertain whether the index can change thorough the year [9]; however, since we are comparing population size values between experimental and control areas, yearly changes in detection probability should affect the different areas in a similar way, so that comparisons are still valid.

All counts were carried out between 9-14h, which is the period with maximum detectability [11]. We carried out a minimum of 3 counts per square within each sample period and used the mean of the three values. Whenever one of the censuses was clearly different from the mean value (>50%) we carried out two additional censuses and used the mean value. Population size surveys were carried out 9-25 February, 8-24 June, 19 October-4 November and 28 December-15 January. These periods are denominated as the February, June, October and January census.

Data were analyzed with a repeated measures ANOVA, where census data from each district were paired. Feral pigeon density (number of pigeons by 6.25 ha), at each of the sampled squares, was the dependent variable. Independent variable Time included the four paired census periods previously detailed (February, June, October and January). Independent variable District included the two experimental districts (SA and HG) and the control district.

For the district of SA, where most squares were monitored, we tested several variables for correlation to population size. i). Food availability provided by people. We ranked food deposited in streets 1: <200g, 2: 200-500g, 3: 500-1,000g, 4: 1,000-3,000g of food per square and day. Food availability was estimated by information agents meanwhile visiting each square to inform people. The quantity of food (according to the previous scale) found at different points within each square were summed to obtain a daily estimation of food available per square. Values estimated from different days were averaged. ii). Reduction in food supply. The main aim of the information agents was to make citizens aware of the problems of feeding pigeons and that people do not continue to provide food to the birds. We computed an index of variation in food availability as the quantity of food available in the period between the first two censuses minus the quantity of food available in the period between the last two censuses. The reduction in food supply in SA district was tested comparing the quantity of food available to pigeons (semi quantitative scale, see i) between the two periods (see ii), within each square, which were paired, using a non-parametric Wilcoxon Matched Pairs test. iii). Culling effort. We used the total number of pigeons captured per square. This data set was analyzed with a multiple regression, using ranked data to avoid problems related to the lack of normality in the variables used [27,28]. The dependent variable included the reduction in the number of pigeons at the squares of the SA district (census 4 - census 1), and independent variables included absolute quantity of food provided by people (i), reduction in the quantity of food available per square since the start of the experiment (ii), and number of pigeons culled at each square (iii) (N=32 squares).

Body measures were recorded for a sample of individuals (N=483) from the different sampling units at the start (1 February) and at the end of the experiment (13 November). For each individual we measured body mass, skull length and wing length with a ruler to the nearest mm. Additionally, an index of body condition was computed by regression using standardized residuals of body mass and skull length [29].

3. RESULTS

At the start of the experiment, the density of pigeons at the SA district was higher than at the HG and control districts (figure 2)(Post hoc Planned Comparison tests; SA *vs.* HG: $F_{1,53}$= 9.26, p<0.01; SA *vs.* CTL: $F_{1,53}$= 9.92, p<0.01; HG *vs.* CTL: $F_{1,53}$= 0.01, p=0.93). The number of pigeons at the two experimental districts was reduced by a 40% between February and June (figure 2)(Post hoc Planned Comparison tests; SA: $F_{1,53}$= 75.90, p<0.001; HG: $F_{1,53}$= 9.84, p<0.01). Number of pigeons at the control district did not vary during the study (Feb *vs.* June: $F_{1,53}$= 0.44, p=0.51; whole period: $F_{1,53}$= 0.51, p=0.48)(figure 2, note significant interaction between Districts and Time).

The quantity of food available to pigeons from the start to the end of the study was significantly reduced in the study area (Median 1.5 *vs.* 1.0 units of food by square; Wilcoxon Matched Pairs Test: Z= 2.58; p<0.01; N=32;). The reduction in the number of pigeons at the squares of the SA district (census 4 - census 1) was correlated to the reduction in the quantity of food available per square since the start of the experiment (r partial= 0.37, p<0.05), so that squares with a higher reduction in food availability reduced population size to a higher degree. The number of pigeons culled at each square (mean value= 159; 95% CI: 94-224) and the absolute quantity of food provided by people had no effect on the reduction in pigeon density (culled individuals r partial= 0.07, p=0.72; food availability r partial= -0.18, p=0.33; N=32 squares).

Pigeons captured at the end of the experiment were larger by 1-3% than at the start of the study, before culling and public information were implemented (figure 3). The body condition of pigeons, however, was reduced during the study by a 6% (figure 3).

4. DISCUSSION

The sustainable reduction of the number of pigeons in urban habitats is one of the main aims of urban wildlife managers [4]. As in the case of other urban nuisance wildlife, reducing the food provided by humans should be the target of managers [4,9,30]. However, this is rarely attempted, especially in large cities (see an exception in Haag-Wackernagel [5] and Giunchi et al. [4]). Results from our experimental study in Barcelona city showed that public education aimed to reduce the food base, succeeded in reducing both food available and feral pigeon abundance.

Pigeon abundance was reduced by 40% between February and June and did not increase until the following January. The effect was not apparent in the control areas, where no action was carried out. The reduction in the number of pigeons was mainly affected by the reduction in the quantity of food available to pigeons rather than by the culling actions. In fact, culling reduces pigeon density at the capture sites but if food abundance is not reduced simultaneously the pigeons from the surroundings quickly refill the emptied area so that in a few days the density recovers [13]. Instead, the reduction of food availability has permanent effects, since the area cannot hold the same number of pigeons as before. Hence, data strongly support the view that the reduction of the carrying capacity of the environment through food reduction is the best way to attain an efficient feral pigeon population size control [4,5].

The main reduction in pigeon abundance was attained in just four months. This period probably may be enough to cause a reduction in pigeon survival and breeding success when linked to a reduction in food availability. However, given the fast dispersal responses of feral pigeons to variations in food availability and pigeon density [13], it is also possible that a part of the population emigrated from the experimental squares to other areas of the city, so that the reduction found in pigeon numbers could be the combined effect of both processes. Nevertheless, and from the perspective of a city manager, pigeon numbers were successfully reduced permanently whatever the main reason for the reduction.

The lack of variation in pigeon density in the control area along the year is surprising. Population size should increase for instance during and after the breeding season, and should decrease after the late summer population crisis. We think that stability found in the control area may be a by-product of using a constant detectability along the year when in fact, this detectability most probably changes according to period [9]. During the breeding season, detectability should be reduced and the correction factor should increase, since many females may be incubating and hence, are not available during census. Detectability of juvenile birds may also be different from that of adult birds. All of this can mask census values. Nevertheless, we have to emphasize that this does not affect to the main results of the paper, since we are comparing experimental and control sample units and detectability should probably covary between units in a similar way.

It has been shown earlier that in urban pigeon populations where people provide abundant food, pigeons are selected for longer tarsi, while short tarsi are selected for in populations with less feeding [16]. Population size management also had an effect on the size and body condition of the pigeons. Skull and wing length increased and body mass and body condition decreased. This could be a consequence of a trapping bias, if the first captures were a biased part of the population. However, this is improbable since the birds to be trapped first, and being removed from the population, would have been dominant and large individuals that monopolize abundant food sources [17]. Alternatively, our results could be interpreted as a consequence of dominant and hence larger individuals, being favoured because of their priority of access to the reduced food supplies [17,18]. It could also be that the smaller birds (as young individuals or females) emigrate first from the experimental squares. In both scenarios, the presence of high competence to access reduced food resources may have caused the reduction in the body condition of the birds. Whatever the case, results show how reducing food availability and distribution because of control operations can exert important selection pressure that can change population composition.

Summarising, reducing feral pigeon abundance in cities is clearly better achieved by reducing the food provided by humans, and public education aimed to reduce the food base should be the target of managers.

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Reference List

1. Johnston RF, Janiga M, Feral pigeons. Oxford University Press, New York, (1995).

2. Bevan RDR. The Costs of Feral Pigeons. Feral Pigeons. Biology-Problems-Control; London: British Ornithological Union; 1990 p. 10-1.

3. Haag-Wackernagel D, Parasites from feral pigeons as a health hazard for humans. *Annals of Applied Biology* **147**:203-210 (2005).

4. Giunchi D, Albores-Barajas YV, Baldaccini NE, Vanni L, Soldatini C, Feral Pigeons: Problems, Dynamics and Control Methods. In: *Integrated Pest Management and Pest Control - Current and Future Tactics,* ed. by Soloneski S pp. 215-40, (2012).

5. Haag-Wackernagel D, Regulation of the Street Pigeon in Basel. *Wildl Soc Bull* **23**:256-260 (1995).

6. Dobeic M, Pintaric S, Vlahovic K, Dovc A, Feral pigeon (*Columba livia*) population management in Ljubljana. *Veterinarski Arhiv* **81**:285-298 (2011).

7. Haag-Wackernagel D, Geigenfeind I, Protecting buildings against feral pigeons. *European Journal of Wildlife Research* **54**:715-721 (2008).

8. Ragni B, Velatta F, Montefameglio M, Restrizione dell'habitat per il controllo della popolazione urbana di *Columba livia*. In: *Control of Synanthropic bird populations: problems and prospectives,*WHO/FAO; Roma, pp. 106-10, (1996).

9. Giunchi D, Baldaccini NE, Sbragia G, Soldatini C, On the use of pharmacological sterilisation to control feral pigeon populations. *Wildlife Research* **34**:306-318 (2007).

10. Ballarini G, Baldaccini NE, Pezza F, Colombi in città. Aspetti biologici, sanitari, giuridici. Metodologie di controllo. Ist.Naz.Biol.Selvaggina, Documenti Tecnici 6, Giugno, (1989).

11. Uribe F, Colom L, Camerino M, Ruiz J, Senar JC, Censo de las palomas semidomésticas (Columba livia var.) de la ciudad de Barcelona. *Misc Zool* **8**:237-244 (1984).

12. Senar JC, Carrillo-Ortiz J, Arroyo L, Montalvo T, Peracho V, Estima de la abundancia de Palomas (*Columba livia var.*) de la ciudad de Barcelona, 2006 y valoración de la efectividad del control por eliminación de individuos. *Arxius de Miscle·lània Zoològica* **4**: (2009).

13. Sol D, Senar JC, Urban pigeon populations: stability, home range, and the effect of removing individuals. *Can J Zool* **73**:1154-1160 (1995).

14. Walter GH, Hengeveld R, Autecology: Organisms, Interactions and Environmental Dynamics. CRC Press, Boca Raton, (2014).

15. Nosil P, Ecological Speciation. Oxford University Press, Oxford, (2012).

16. Sol D, Artificial selection, naturalization, and fitness: Darwin's pigeons revisited. *Biological Journal of the Linnean Society* **93**:657-665 (2008).

17. Murton RK, Coombs CFB, Thearle RJP, Ecological studies of the feral pigeon Columba livia var.: II. flock behaviour and social organization. *J appl Ecol* **9**:875-889 (1972).

18. Sol D, Santos DM, Cuadrado M, Age-related feeding site selection in urban pigeons (*Columa livia)*: experimental evidence of the competition hypothesis. *Can J Zool* **78**:144-149 (2000).

19. Williams BK, Nichols JD, Conroy MJ, Analysis and Management of Animal Populations: Modeling, estimation, and decision making. Academic Press, New York, (2002).

20. Senar JC, Sol D, Censo de Palomas *Columba livia var.* de la ciudad de Barcelona: Aplicación del muestreo estratificado con factor de corrección. *Butll GCA* **8**:19-24 (1991).

21. Conroy MJ, Carroll JP, Quantitative conservation of vertebrates. Wiley-Blackwell, Oxford, (2009).

22. Giunchi D, Gaggini V, Baldaccini N, Distance sampling as an effective method for monitoring feral pigeon (*Columba livia f. domestica*) urban populations. *Urban Ecosystems* **10**:397-412 (2007).

23. Giunchi D, Vanni L, Soldatini C, Albores-Barajas YV, Baldaccini NE, Old and novel methods for estimating Feral Pigeons (*Columba livia f. domestica*) population size: a reply to Amoruso et al. (2013). *Urban Ecosystems* **17**:719-722 (2014).

24. Sacchi R, Razzetti E, Gentilli A, A methodological approach to feral pigeon (*Columba livia*) census in urban areas. *Rivista Italiana di Ornitologia* **75**:119-27 (2007).

25. Sacchi L, Gentilli A, Razzetti E, Barbieri F, Effect of building features on density and flock distribution of feral pigeons *Columba livia var. domestica* in an urban environment. *Can J Zool* **80**:48-54 (2002).

26. Barbieri F, De Andreis C, Indagine sulla presenza dei colombi (*Columba livia* forma *domestica*) nel centro storico di Pavia e nell'oltrepò pavese (U.S.L. N. 79, Voghera). *Suppl Ric Biol Selvag* **17**:195-198 (1991).

27. Conover WJ, Rank transformations as a bridge between parametric and nonparametric statistics. *Amer Statistician* **35**:124-129 (1981).

28. Conover WJ, IMAN RL, Analysis of covariance using the rank transformation. *b* **38**:715-724 (1982).

29. Brown ME, Assessing body condition in birds. *Current Ornithology* **13**:67-135 (1996).

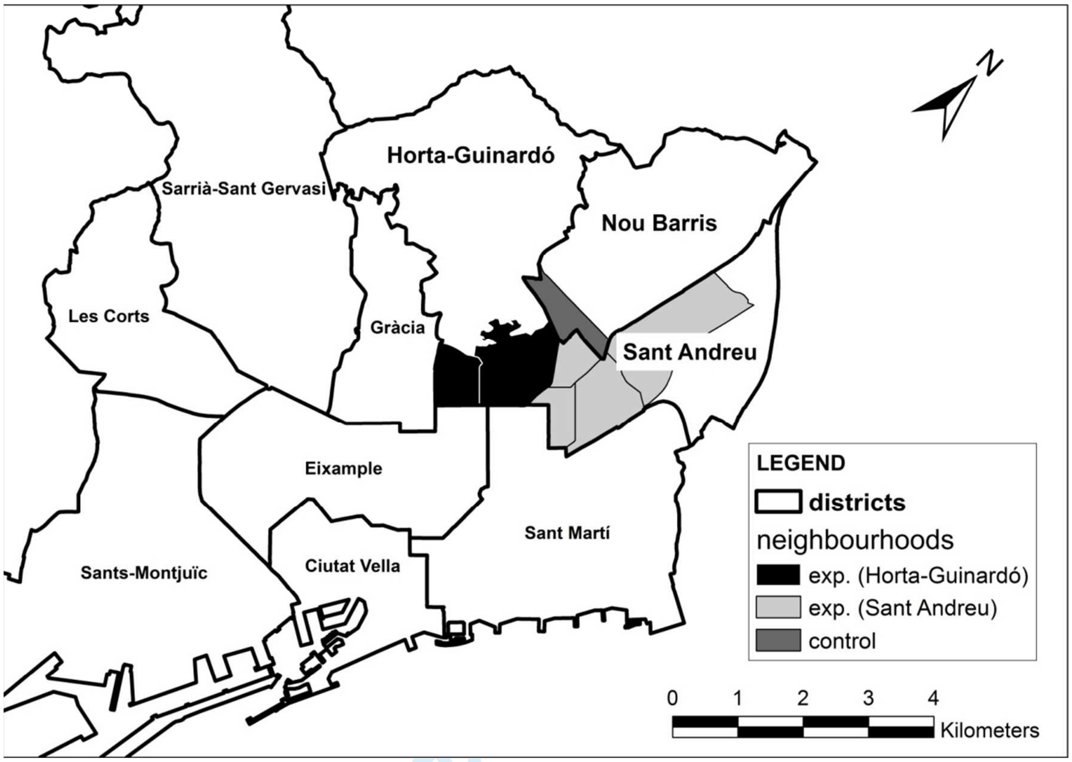
30. Adams CE, Lindsey KJ, Ash SJ, Urban Wildlife Management. CRC Press, New York, (2006).

Figures

Figure 1. Map of Barcelona showing in black and light grey the neighbourhoods where we carried out the experimental work (in the Sant Andreu and Horta-Guinardó districts, respectively), and in dark grey the neighbourhood used as a control.

Figure 2. Variation in population density of feral pigeons in the two experimental districts (Sant Andreu- black circles and Horta Guinardó- black squares) and the control district (Nou Barris: open diamonds), according to the population surveys. Error bars refer to S.E. Time included four paired census periods: February (9-25 Feb), June (8-24 Jun), October (19 Oct-4 Nov) and January (28 Dec-15 Jan). RMANOVA analysis: District $F_{2,159}$= 5.13, $p<0.01$; Time $F_{3,159}$= 13.17, $p<0.001$; District x Time $F_{6,159}$=3.60, $p<0.001$. When comparing census 1 with 2 we found significant reductions in number of pigeons for Sant Andreu ($F_{2,153}$= 75.90, $p<0.001$) and Horta-Guinardó ($F_{2,153}$= 9.84, $p<0.01$), but not for the Control district ($F_{2,153}$= 0.44, $p=0.51$). Comparisons between census 3 and 4 were not significant for the three districts (all $p>0.23$).

Figure 3. Variation in morphometry of feral pigeons captured in the Sant Andreu district prior to and after management operations. Error bars refer to S.E. ANOVA results for body mass: $F_{1,481}$= 8.70, $p<0.01$; body condition: $F_{1,481}$= 32.65, $p<0.001$; skull length: $F_{1,481}$= 64.17, $p<0.001$; wing length: $F_{1,481}$= 12.35, $p<0.001$.



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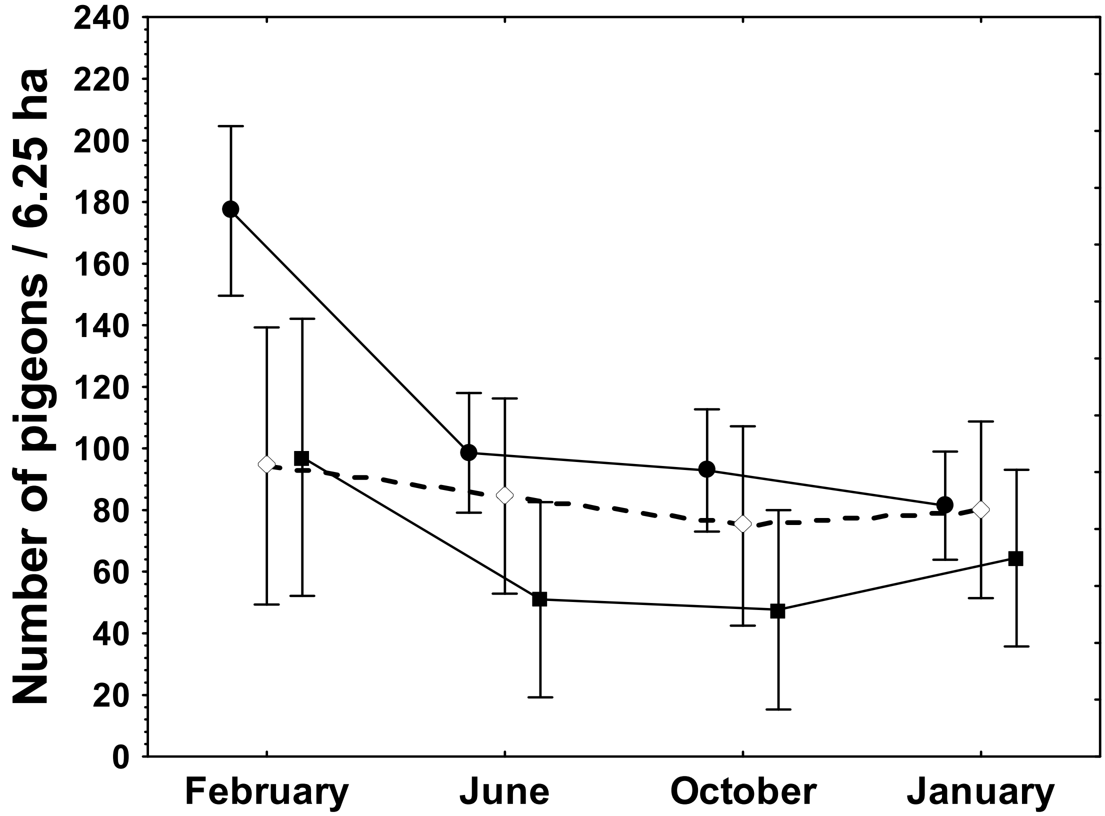
369 Figure 1


Number of pigeons / 6.25 ha
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200
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February
June
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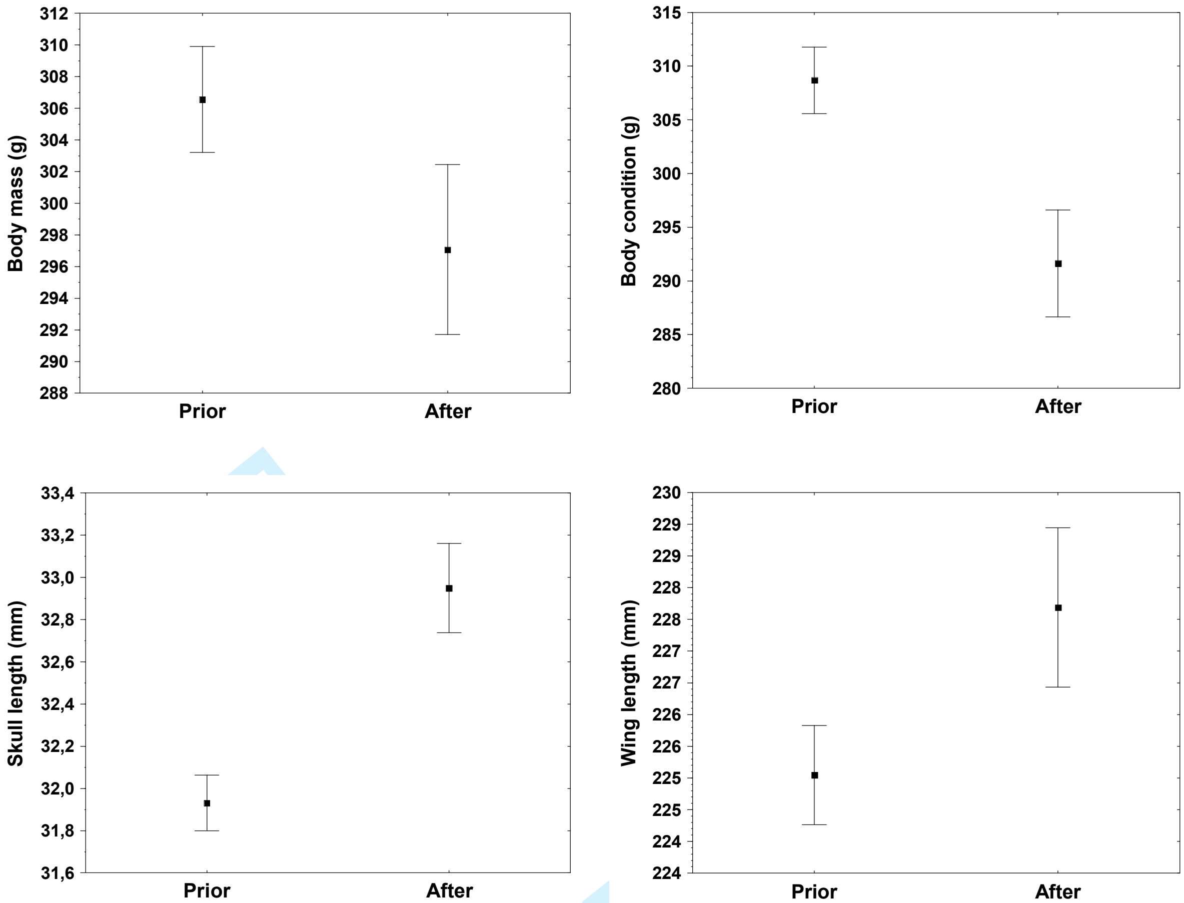
Figure 2


Body mass (g)
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302
300
298
296
294
292
290
288
Prior
After
Body condition (g)
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310
305
300
295
290
285
280
Prior
After
Skull length (mm)
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33,2
33,0
32,8
32,6
32,4
32,2
32,0
31,8
31,6
Prior
After
Wing length (mm)
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229
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224
Prior
After

Figure 3